Chapter 3
Lipid Chemistry

→ **Lipids :** Organic compounds insoluble in water but soluble in organic solvents i.e. ether , benzene , acetone & chloroform

→ Biomedical Importance :

→ 1. Source of energy (Lipids have a high energy value)

1 gm of lipids 9.3 Kilocalo

→ 2. Supply body e` :

1 • Fat soluble vitamins (vit. K , E , D & A)

2 • Essential Fatty acid (α Linolenic & Linoleic acids)

Classification :

Lipids

→ **Simple Lipids**
Esters of FA e` with alcohols

Complex (Compound) or Conjugated Lipids
Simple lipids conjugated e` another group

Derived Lipid
Produced from hydrolysis of lipids

Fatty Acids "FA" R-COOH

Def. : Mono carboxylic organic acids, mostly contain even No. of carbons

Occurrence :

- Esterified e` alcohols : In natural fat , oils & waxes
- Unesterified : In plasma carried on albumin Free FA FFA

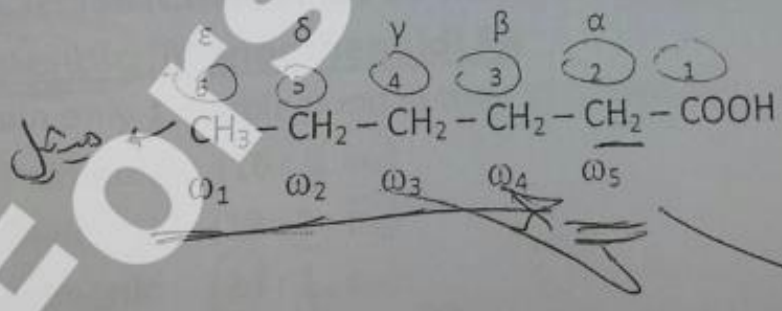
Numbering of the carbon skeleton of FA

1. Starting from the carboxyl group :

- Give COOH No. 1 then proceed to the terminal CH_3
- α, β, γ .. system: the 1st carbon following COOH is α then proceed to the terminal CH_3

2. Starting from the terminal methyl group (omega " ω" carbon) :

- The terminal methyl carbon is given ω_1 then proceeds to COOH group



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Classification of Fatty Acids "FA"

Fatty Acids

Saturated FA (SFA)
Contain No double bonds

- **Short chain FA**
  Less than 10 carbons
  - Acetic acid C_2
  - Butyric acid C_4
  - Caproic acid C_6
- **Long Chain FA**
  More than 10 carbons
  - Palmitic acid C_{16}
  - Stearic acid C_{18}
  - Lignoceric acid C_{24}

Unsaturated FA (USFA)
Contain 1 or more double bonds

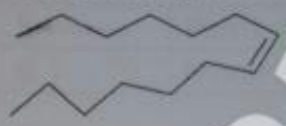
Most Important FAs :

Q : Palmitic & Stearic acids are the most important FAs ..... Why ?
As : They are widely distributed in diet
Q : What is the commonest FA in animal tissues ?
Answer : Palmitic acid → C_{16}

Unsaturated FA contain 2 types of double bonds :

1. **Cis type :**
   - Groups at the same side of the double bond
   - Allow bending of the chain at the double bond → ↓ Melting temperature so, they are liquids room temperature
2. **Trans type :**
   - Groups at the opposite side of the double bond
   - FA containing trans double bonds are linear and solid at room temperature

NB. : Naturally occurring USFA contain double bonds of the cis type



Cis double bond "bending of FA"

Trans double bond "linear FA"

Classification of FA according to No. of double bonds

1. Monoenoic (Monoethenoid) FA :

- Contain only 1 double bond in their structure as :
  - Palmitoleic (16 : 1, ω_7)
  - Oleic (18 : 1, ω_9)
  - Nervonic (24 : 1, ω_9)

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2. Polyenoic (Polyethenoid) FA or PUFA :

- Contain more than 1 double bond in their structure
- Classified according to the No. of double bonds into diethenoid, triethenoid.....etc.

N.Bs :

1. In poly unsaturated FA each 2 double bonds are separated by methylene group ($-CH_2$)
2. PUFA are classified according to the position of the 1st double bond in relation to ω carbon into ω_3, ω_6, ω_7 & ω_9 FA

A. ω_3 PUFA :

- PUFA having the 1st double bond at carbon 3 in relation to ω carbon
- **Examples:**
  1. α Linolenic acid (18 : 3) → Parent FA
  2. Timnodonic acid (20 : 5)
  3. Cervonic acid (22 : 6)
- α linolenic is the precursor of other members of this group in the body (Parent FA)

B. ω_6 PUFA :

- PUFA having the 1st double bond at carbon 6 in relation to ω carbon.
- **Examples:**
  1. Linoleic acid (18 : 2) → Parent FA
  2. γ Linolenic acid (18 : 3)
  3. Arachidonic acid (20 : 4)
- Linoleic acid is the precursor of other members of this group (Parent FA)

Most important Unsaturated FAs :

Double bonds	Name	Example
1	Monoethenoid FA	Palmitoeleic , Oleic & Nervonic
2	Diethenoid FA	Linoleic
3	Triethenoid FA	Linolenic
4	Tetraethenoid FA	Arachidonic
5	Pentaethenoid FA	Timnodonic
6	Hexaethenoid FA	Cervonic

Nutritional Classification of FA

1. Essential FA :

Def.: FA can't be synthesized inside the body & should be supplied in diet

Essential FA are :

1. α linolenic (Precursor of ω_3 family)
2. Linoleic (Precursor of ω_6 family)

NB. : Other members of ω_3 & ω_6 families are formed from α linolenic & linoleic by desaturation & elongation

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Sources of PUFA :
1. Fish oils.
2. Vegetable oils (linseed, Cotton seed, Maize, Olive & Sunflower oils)

Deficiency of essential FA leads to :
Adults : fatty liver & sterility
Children : Retardation of growth & dermatitis

2. Non Essential FA
Def.: FA w' can be synthesized inside the body
Examples : The rest of the FA i.e. palmitic , stearic ... etc.

Properties of Fatty Acids

A. Physical Properties :

1. Melting point :
- Short chain SFA < 10 Carbons ⟶ Low melting (oily liquids)
- Long chain SFA > 10 Carbons ⟶ High melting point (solids)
- Unsaturated long chain FA ⟶ Liquids as they contain cis double bonds

2. Solubility in water :
- Short chain FA < 6 carbons ⟶ Soluble in water
- Long chain FA > 6 carbons ⟶ Insoluble in water
- Solubility decreases as the chain becomes longer

B. Chemical Properties

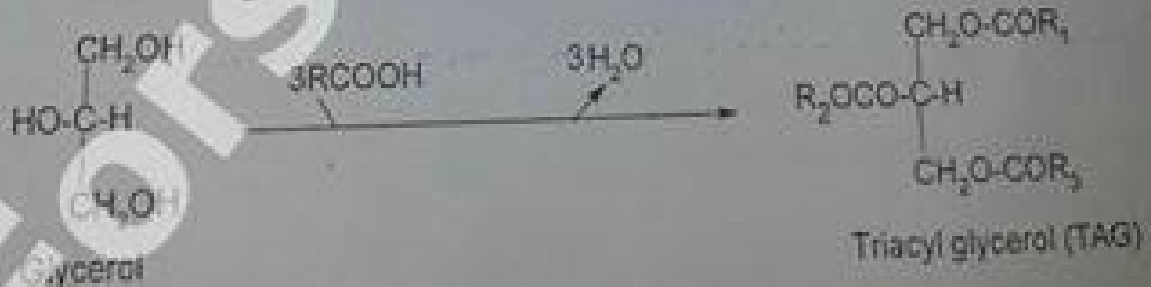
I. Properties due to carboxyl group :

1. Salt formation :

FA reacts with alkali to form the corresponding salt

NB. : Soap: Alkali salt of FAs

2. Ester formation :



Glycerol

Triacyl glycerol (TAG)

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3. Reduction :

Fatty acid $\xrightarrow{\text{Reduction}}$ Fatty aldehyde $\xrightarrow{\text{Reduction}}$ Fatty alcohol

$$\text{R-COOH} \xrightarrow{2H,\ -H_2O} \text{R-CHO} \xrightarrow{2H} \text{RCH}_2\text{OH}$$

FA — Fatty aldehyde — Fatty alcohol

II. Properties due to presence of double bonds :

1. Addition of hydrogen :

Addition of hydrogen to the double bond of USFA ⟶ Corresponding SFA

$$\text{Oleic acid (18 : 1)} \xrightarrow{2H} \text{Stearic acid } (C_{18}) \xleftarrow{4H} \text{Linoleic acid (18 : 2)}$$

2. Addition of Iodine :

Each double bond reacts with 2 atoms of Iodine

$$\text{- CH = CH -} \xrightarrow{I_2} \text{- CH(I) – CH(I) –}$$

Oleic acid — Di iodo stearic

3. Addition of Oxygen :

- Presence of double bonds make FA sensitive to oxidation.
- Double bonds reacts with O_2 to form ⟶ Peroxides

$$\text{-CH = CH -} \xrightarrow{O_2} \text{- CH(O) - CH(O) -}$$

USFA — Peroxide

- Further oxidation ⟶ Lower chain aldehyde & FA
- Oxidation of USFA (Peroxidation) ⟶ Destruction of lipoproteins of cell membrane

NB. : Peroxides have bad smell & taste

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Eicosanoids

- Derivatives of C_{20} PUFA as :
  1. Arachidonic acid
  2. Timnodonic acid
- Hormone like molecules produced by most mammalian cells
- Active within the cell in w` they are produced (autocrine) or on adjacent cells (paracrine)
- Have many physiological & Pharmacological actions

Nomenclature :

- 1st 2 letters are the abbreviation
- The 3rd letter indicates the type i.e. A , B , C , D , E ....etc.
- Subscript number indicates the No. of double bonds i.e. PGE-

Classification :

Eicosanoids

Cyclic Eicosanoids (Prostanoid)
- Prostaglandins (PG)
- Prosta cyclins (PGI)
- Thromboxanes (TX)

Non cyclic Eicosanoids
- Leukotriens (LT)
- Lipoxins (LX)

Importance of Eicosanoids :

1. **PGE_2 :** → VD, Smooth Ms relaxant
2. **$PGF_{2\alpha}$:** → VC, Smooth Ms contraction
3. **Thromboxane A_2 (TXA_2)** : Synthesized by platelets & produces :
   - VC
   - ↑ Platelets aggregation
4. **Prostacyclin I_2 (PGI_2)** : Synthesized by vascular endothelium & produces :
   - VD
   - ↓ Platelet aggregation
5. **Leukotriens :** → ↑ Vascular permeability, Components of slow reacting substance of anaphylaxis (SRSA) → severe allergic reactions
6. **Lipoxins** → Anti-inflammatory

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Some Chemical hints about Eicosanoids :

1. Prostaglandins :- Derived from C_{20} hypothetical compound termed prostanoic acid
   - Contain cyclopentane ring
   - 1st discovered in prostate
2. Prostacyclins : Contains cyclopentane ring & another additional ring
3. Thromboxanes : Contain oxane ring (ring e` 2 oxygen atoms)
4. Leukotriens :- Non cyclic (contains no rings)
   - Secreted from leukocyte , platelets & mast cells
5. Lipoxins :- Contains more oxygen than leukotriens
   - Secreted from arterial wall

Simple Lipids

Def.: Esters of FA with alcohol.

Classified: According to the type of alcohol into :

Simple lipids

- **Neutral fats (TAG)** — Esters 3 FA with glycerol
- **Waxes** — esters of FA with higher alcohols

Neutral Fats
(Triacyl glycerol "TAG" or Triglycerides)

Glycerol : is the alcohol present in TAG

Fatty acids : FA present in TAG are usually of different types (SFA & USFA)

Neutral fats (TAG) are classified into 2 subgroups :

1. **Oils** :- Have low melting temperature
   - Liquids at room temperature due to their content of USFA
   - i.e. sunflower, cotton seed, linseed & maize oils
2. **Solid fats** :- Have high melting temperature
   - Solid at room temperature due to their high content of SFA
   - i.e. butter & margarine

Properties of Neutral Fats

A. Physical properties :

- TAG is colorless, odorless & tasteless
- The yellow color is due to presence of carotenoids
- Insoluble in water & soluble in fat solvents

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B. Chemical properties :

1. Hardening (Reduction) :

Def. : Hydrogenation of oils to form solid fat or margarine

As : USFA are converted to SFA

2. Iodine Number :

Def.: Number of grams of Iodine absorbed by 100 gm fat or oil

- It' an index of saturation
- It's higher in oils due to their high content of USFA

3. Hydrolysis of TAG :

a. **Acid Hydrolysis :**

Boiling TAG with acids ⟶ Glycerol + 3FAs

b. **Alkaline Hydrolysis (Saponification) :**

Def.: Hydrolysis of TAG using alkalis

- Produces Glycerol & Soap
- Soap: Alkaline salt of FA

TAG $\xrightarrow{3KOH}$ Glycerol + $3RCOO^-K^+$ (K soap)

c. **Enzymatic Hydrolysis :**

TAG by lipase enzyme gives glycerol & 3 FAs

4. Rancidity :

Def.: Development of bad flavor (odor & taste) of fats or oils

Causes : Exposure to *MOHM*

- Moisture
- Oxygen
- High temperature
- Metal (act as a catalyst)

Types : Hydrolytic & oxidative

1. Hydrolytic Rancidity :

Cause: Due to presence of

- Moisture (H_2O)
- Bacteria (Contain lipase enzyme)

- Lipase causes release of short chain FAs which are volatile
- Short chain FAs responsible for the bad odor & taste

2. Oxidative Rancidity :

- Oils are more liable to develop this type of rancidity .....*why?*

As : they are rich in USFA.

- Oxidation of USFA ⟶ Peroxides, ketones & aldehydes ⟶ Bad flavor

Q : Addition of vit. E , phenols & quinones may prevent oxidative rancidity .....*Why ?*

As : vit. E , phenols & quinones are antioxidants so protects USFA against oxidation

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Waxes

Def.: Esters of long chain FA with long chain alcohols
Site: Trunks of trees & fur of animals
Function: Acts as a protective coat
Examples:
1. True wax (Bee's wax) : Esters of palmitic acid e` mericyl alcohol (C30)
2. Lanolin (in hair) : Esters of cholesterol derivatives.
3. Vit A (Retinol) esters
4. Vit D (Calciferol) esters

2. Conjugated Lipids

Def. : Simple lipids conjugated with another group
Classified into :
A. Phospholipid : containing phosphate
B. Glyco lipid : containing carbohydrate

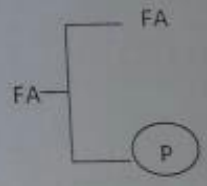
Phospholipids

Classified according to the alcohol present into :
A. Glycerophosphatides (Phosphoglycerides) : Containing glycerol
B. Sphingomyelin : Containing sphingosine (sphingol)

A. Glycerophosphatides (Phosphoglycerides)

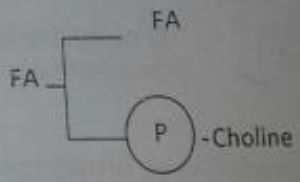
- Phospholipids containing glycerol as alcohol
- They are derivatives of phosphatidic acid

1. Phosphatidic acid :



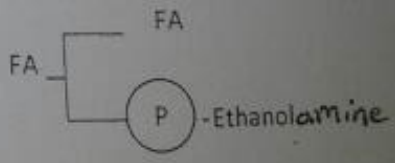
- Diacylglycerol phosphate
- Formed during synthesis of TAG & phospholipid
- FA at position 1 is SFA & at position 2 USFA
- Other phosphoglycerides are formed by conjugation of different groups to phosphate

2. Lecithin (Phosphatidyl choline) :



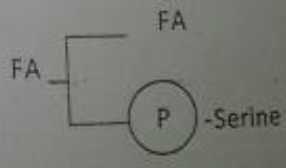
- Formed of phosphatidic acid + choline

3. Cephalin (Phosphatidyl ethanolamine) :



- Formed of phosphatidic acid + ethanolamine

4. Phosphatidyl serine :



- Formed of phosphatidic acid + serine

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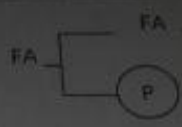
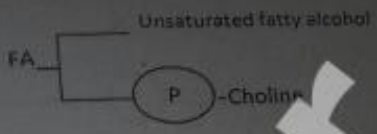
5. Phosphatidyl Inositol (Lipositol) :

- Formed of phosphatidic acid + Inositol



6. Plasmalogens :

- Same structure as lecithin but FA at position 1 is replaced by unsaturated fatty alcohol.



7. Cardiolipins (Diphosphatidyl glycerol) :

- Formed of 2 molecules of phosphatidic acid connected by 1 molecule of glycerol
- **Hydrolytic products :** 4FA + 3 Glycerol + 2 Phosphate

8. Phosphatidyl glycerol :

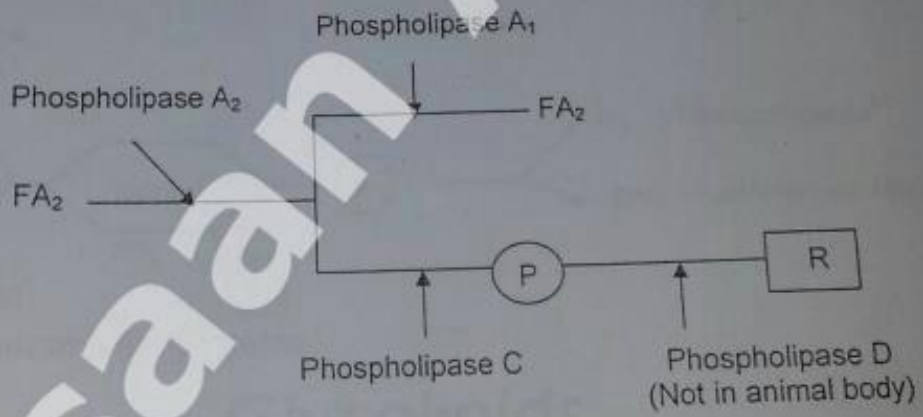
- Formed of phosphatidic acid + glycerol

9. Lysophospholipids :

- By the action of phospholipase A_2 on different phospholipid

Hydrolysis of Glycerophosphatides

Phospholipases : Hydrolyzes different phospholipids



Q : Snake venom causes death.....*why?*

As : it contains lecithinase, when injected into blood converts phospholipid in cell membran of RBCs to lysophospholipid ⟶ Hemolysis

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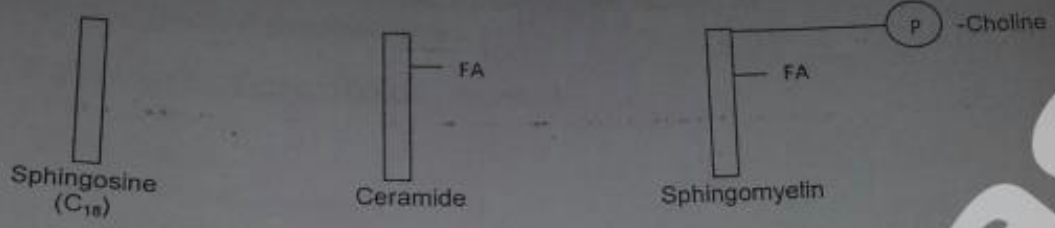
B. Sphingomyelin

- Present in myelin sheath of brain & in cell membranes.
- Contain the alcohol sphingosine "sphingol".
- FA is linked to sphingosine by amide bond forming ceramide.
- Ceramide + phosphate + choline = sphingomyelin.



Importance of Phospholipids ALPHEC

1. Arachidonic acid is provided from cell membrane phospholipid for synthesis of eicosanoids
2. Lung surfactons are dipalmitoyl lecithin
3. Platelet Activating Factor (PAF) is a choline plasmalogen
4. Hormone second messengers:
   Activation of phospholipase C hydrolyzes phosphatidyl inositis bisphosphate (PIP_2) into :
   - Inositol tris phosphate (IP3) $\rightarrow\uparrow$ intracellular Ca^{2+}
   - DAG $\rightarrow$ Activates protein knase C

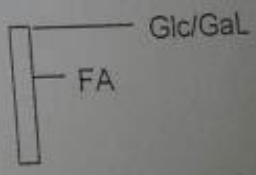
5. Emalisification of fat
6. Cell membrane & plasma lipoproteins

Glycolipids

- Formed of ceramide (sphingosine + FA) attached to carbohydrates
- Includes Cerebrosides, Sulfolipids & Gangliosides

1. Cerebrosides :

- Formed of ceramide + Glucose (glucocerebroside) / Galactose (galactocerebroside)
- FA contain 24 carbons: Cerebronic / Nervonic



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2. Sulfolipids (sulfatides) :
- Formed of ceramide + galactose 3 sulfat

Gal-3 sulfate
FA

3. Gangliosides :
- Formed of ceramide + complex carbohydrate radicals as NANA or N-acetyl galactosamine

Complex CHO
FA

Importance of glycolipids : Found in
- Cell membranes
- Myelin sheath
- Receptors for hormones.

Q1: Enumerate sphingolipids :
- Sphingomyelin
- Glycolipids → Cerebrosides, Sulfolipid, Gangliosides

Q2 : Enumerate choline containing lipids:
- Lecithin
- Plasmalogen
- Sphingomyelin

3. Derived Lipids

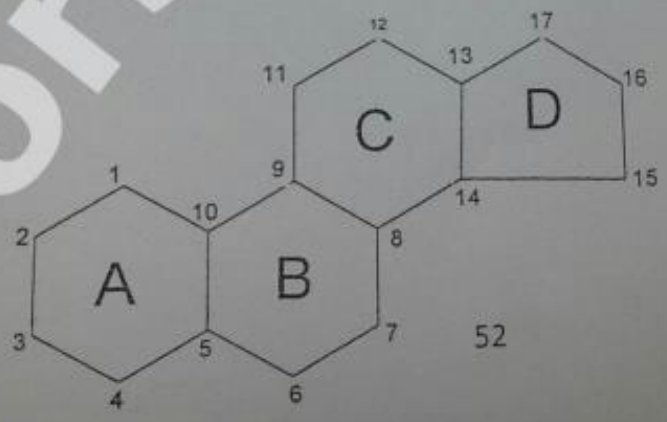
Def.: Produced by hydrolysis of simple or conjugated lipids or associated with lipids in nature.

Includes :

1. **FA**
2. **Alcohols** i.e. glycerol , Sphingosine
3. **Steroids**
4. **Carotenoids**
5. **Fat soluble vitamins** (Vit. K, E, D & A)

Steroids

Compounds containing steroid nucleus (cyclo pentane perhydro phenanthrene "CPPP")



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Steroids

Sterols | Bile acids | Steroid hormones

1. Sterols

Classified into :

a. **Zoosterols :** in animals as cholesterol
b. **Phytosterols :** in plants
c. **Mycosterols :** in yeasts & fungi .

Cholesterol

Structure :

- Most important sterol
- Contain 27 carbons
- OH at C_3 & double bond Between C_5 & C_6

Building units : Acetyl CoA (active acetate)

Plasma cholesterol :

- Synthesized by the liver
- Normal range : 120 – 240 mg / dl

Site : Nervous tissues (Myelin sheath) , Gonads & adrenals

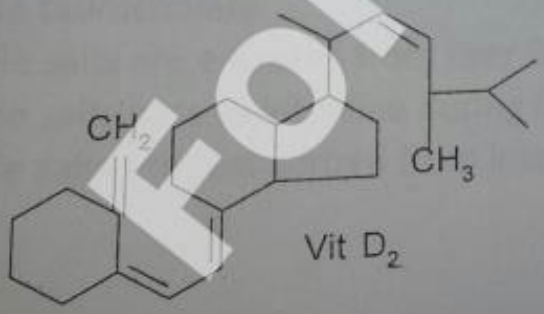
Excretion :

- Mainly as bile salts
- Reduced by intestinal bacteria to coprostanol → stool

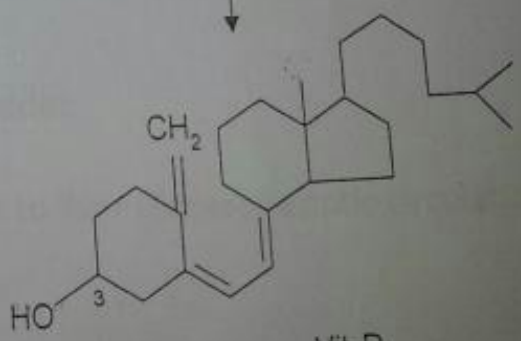
Importance : Formation of

1. Cell membranes (Myelin sheath)
2. Bile salts (in liver)
3. Steroid hormones (in adrenals & gonads)
4. Vit D_3 (Cholecalciferol)

Cholesterol —(7 dehydrogenase, Liver)→ 7 dehydrocholesterol —(Under skin, UVR)→ Vit D_3



Vit D_2



Vit D_3

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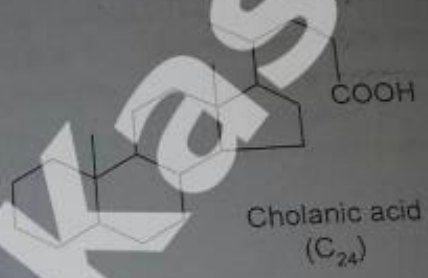
Hazards of hypercholesterolemia : Predisposes to atherosclerosis & coronary heart diseases
Phytosterols : presents in plants & are not physiologically important
Mycosterols : present in yeast & fungi As : Ergosterol

Ergosterol $\xrightarrow{UVR}$ Vit. D_2

N.Bs:
1. Ergosterol is the precursor of Vit D_2
2. Ergosterol & Vit D_2 contain an additional double bond & methyl group in the side chain compared to 7 dehydrocholesterol & vit D_3

Bile acids

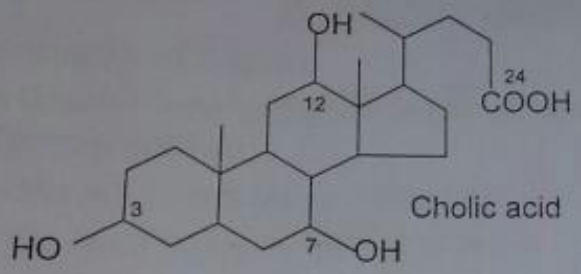
Structure :
- Contain 24 carbons
- Derived from hypothetical compound termed cholanic acid



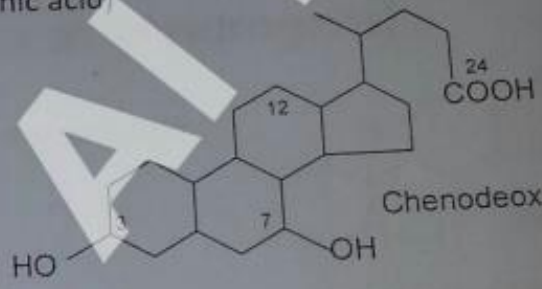
Cholanic acid (C_{24})

Types of bile acids : Primary & Secondry bile acids

1. Primary bile acids
- Cholic acid (3,7,12 trihydroxy cholanic acid)
- Chenodeoxy cholic acid (3,7 dihydroxycholanic acid)



Cholic acid



Chenodeoxy Cholic acid

2. Secondry bile acids
- 2^{ry} bile acids are formed from 1^{ry} bile acids by the action of intestinal bacteria (contain 7α dehydroxylase)

2^{ry} bile acids are :
- Deoxycholic acid (3,12 dihydroxy cholanic acid
- Lithocholic acid (3 monohydroxy cholanic acid)

Bile Salts
- Formed by conjugation of bile acids with glycine or tourine then Na or K to form :
- Na glycocholate
- Na taurocholate
- Bile salts are excreted from liver & stored in gall bladder
- Bile salts pass to intestine during digestion of fat
- Bile salts are reabsorbed from intestine & pass back to liver (Enterohepatic circulation)

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Importance of bile salts : *MDAPS*

1. Main way for excretion of cholesterol
2. Digestion of fat due to emulsification
3. Absorption of fat due to formation of micelle
4. Prevents precipitation of cholesterol & formation of cholesterol stones
5. Stimulates liver cells to secrete more bile (Choleretic effect)

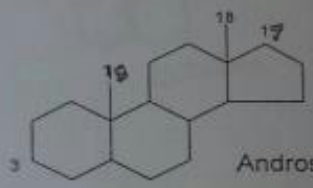
Steroid Hormones

- **Sex Hormones**
  - **Male Sex H (C_{19}) (Androgens)**
    1. Testosterone
    2. Dihydrotestosterone
    3. Androstendione
  - **Female Sex H (C_{21})**
    - **Estrogens**
      1. Estradiol
      2. Estrane
    - **Progesterones**
      1. Progesterone
      2. Pregnandiol
- **Corticoids (C_{21})**
  - **Glucocorticoids**
    1. Corticosterone
    2. Cortisol
    3. Cortisone
  - **Mineralocorticoids**
    1. Aldosterone
    2. 11deoxy-Corticosterone

Sex Hormones

A. Male sex hormones (Androgens)

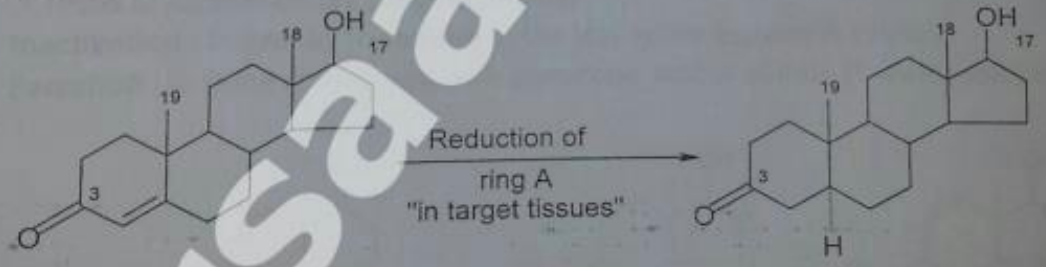
- Contain 19 carbons
- Derived from hypothetical compound termed androstane



Androstane

Testosterone :

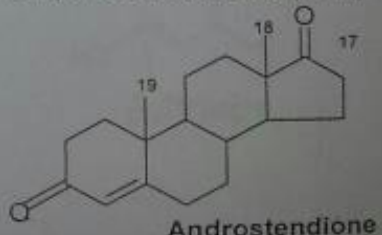
- The main androgen in the body
- Secreted by leydig cells of testis
- Converted in target cells to dihydrotestosterone which is more potent (active form) by reduction of ring A.
- So testosterone is considered as prohormone.



Testosterone — Dihydrotestosterone (DHT)

Other Androgens :

1. Androstendione
2. Androsterone
3. Epi androsterone
4. Dihydroepi androsterone (DHEA)



Androstendione

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Site of Synthesis :

- Testis
- Some androgens are secreted from ovaries & adrenal cortex

Functions of Androgens :

1. Development of ♂ primary sex organs i.e. testis
2. Development of ♂ secondry sex characters :
   - Voice
   - Distribution of hair
   - Distribution of fat

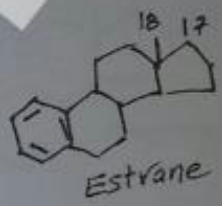
Inactivation : In liver

Excretion :

- In urine conjugated with glucuronic acid to ↑ their solubility in water
- Androsterone & Etiocholanolone forms the major 17 ketosteroids in urine

B. Female Sex Hormones

1. Estrogens



Estrane

- Contains 18 carbons
- Derived from hypothetical compound termed estrane
- Estrogens contain aromatic ring A

Estradiol :

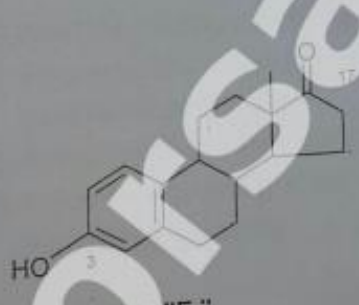
- The most potent estrogen
- Main ♀ sex hormone

Synthesis

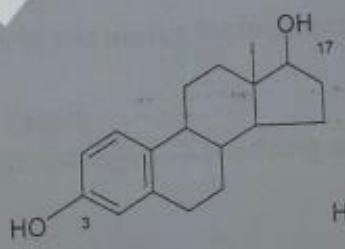
- Ovaries
- Placenta
- Testis & adrenal cortex (small amounts)

Inactivation : In liver by formation of the less active estrone & estriol.

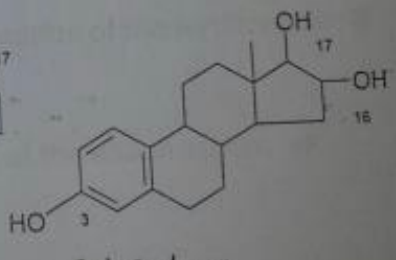
Excretion : In urine conjugated with glucuronic acid or sulfate (↑ water solubility)



Estrone "E_1"



Estradiol "E_2"



Estriol "E_3"

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Functions of Estrogens :

1. Development of ♀ primary sex organs i.e. ovaries & uterus
2. Development of ♀ secondry sex characters
   - Voice
   - Distribution of hair
   - Distribution of fat
   - Breast enlargement
3. Their withdrawal together with progesterone → shedding of the endometrium → menstrual bleeding

N.Bs:

1. Main Androgen: Testosterone
2. Most potent androgen: Dihydrotestosterone (DHT)
3. Main estrogen: Estradiol (E_2) → Most potent

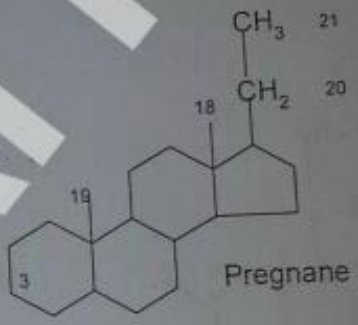
Progesterone

- Contains 21 carbons
- Derived from hypothetical compound termed pregnane

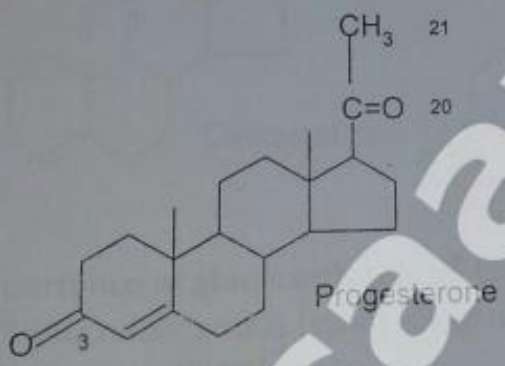
Synthesis : Corpus luteum of the ovary & placenta.

Inactivation : in liver by reduction to pregnandiol

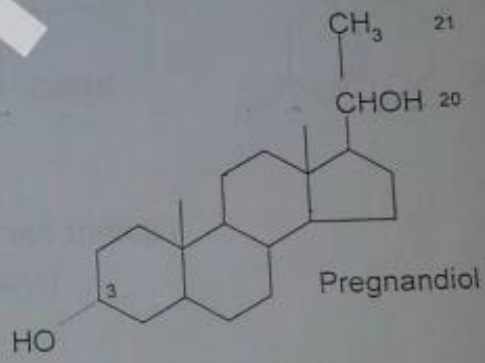
Excretion :Pregnandiol is excreted in urine



Pregnane



Progesterone



Pregnandiol

Functions of progesterone :

1. Prepares the endometrium of the uterus for implantation of the fertilized ova & maintains pregnancy
2. Prepares the breast for lactation
3. Its withdrawal together with estrogen → shedding of the endometrium → menstrual bleeding

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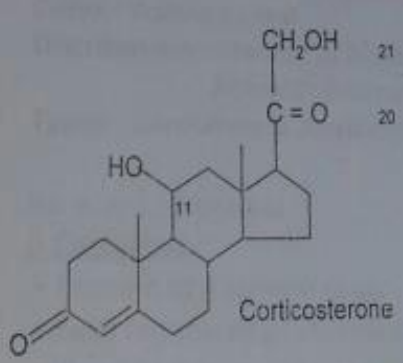
Corticoids

- Secreted from the suprarenal cortex
- Contains 21 carbons
- Derived from pregnane ring
- 2 types :
  1. Glucocorticoids
  2. Mineralo corticoids

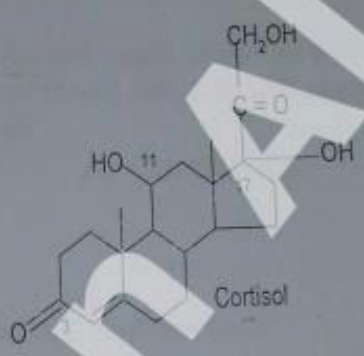
A. Glucocorticoids

They are derivatives of corticosterone

1. **Corticosterone** (progesterone + 2OH at C_{11} & C_{21})
2. **Cortisol**: (or hydrocortisone) : 17 hydroxy corticosterone. It's the most potent glucocorticoid
3. **Cortisone**: 11 dehydro, 17 hydroxy corticosterone



Corticosterone



Cortisol

Cortisone

Importance of glucocorticoids : ↑ blood glucose through

1. ↑ Gluconeogenesis (synthesis of new glucose)
2. ↓ Glucose utilization
3. ↑ Protein break down & lipolysis.

N.B.: Prolonged administration of glucocorticoids result in diabetes mellitus "DM".

B. Mineralocorticoids

Includes :

11-deoxycorticosterone (DOC), also present in synthetic preparation in the form of deoxy corticosterone acetate (DOCA).

Aldosterone:

The most potent mineralocorticoids

Synthesized by adrenal cortex

Similar to corticosterone, but contains aldehyde group at C_{18}

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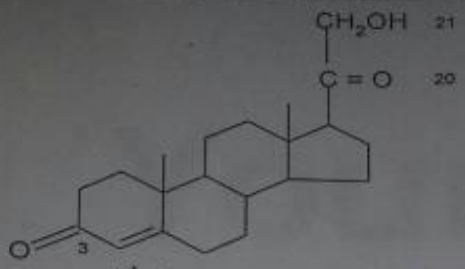
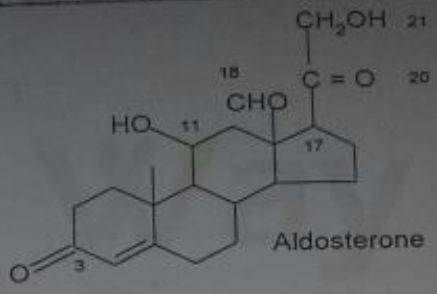


11 deoxy corticosterone
(DOC)



Aldosterone

Importance of Mineralocarticoids :

1. Secretion of K^+ & H^+ and reabsorption of Na^+
2. ↑ In plasma K^+ is the main stimulus for secretion of aldosterone

Carotenoids (Terpenes)

Soluble pigments, widely distributed in plants.

Color : Yellow to red

Distribution : Plants : orange, Apricot, apple, tomatoes and carrots

Animal : Animal fat (TAG), milk, butter & egg yolk

Types : carotenes & Xanthophyls

A. Carotenes

As α, β, γ carotenes

β Carotenes :

- Formed of 2 Ionone rings
- Each Ionone ring is connected to 2 isoprene units
- The 2 isoprene units are connected by 2 methene groups

β Carotene

- β Carotene contains 2 Ionone rings → gives 2 molecules of vit A
- Carotenes gives vit A by 2 enzymes : Carotenase & Retinal reductase
- Retinal reductase requires NADH + H^+ or NADPH + H^+

α & γ Caroenes : Contain only 1 β Ionone ring so give 1 molecule of vit A

B. Oxygenated Carotenes (Xanthophyls)

- The most important member is cryptoxathin
- Cryptoxanthin contains only 1 Ionone ring → gives 1 molecule of vit A.

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